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USE OF MAGNETIC TAPE FOR REPORTING COST INFORMATION

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UNITED STATES AIR FORCE PROJECT RAND

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PREFACE

This memorandum is part of a continuing effort by The Rand Corporation to develop resource analysis methodology for use in Rand and Air Force system studies. It is an exploratory study of a procedure that would reduce the large proportion of costs analysts' efforts devoted to securing, verifying, and analyzing data. The proportion is especially large for analysts responsible for developing cost-estimating relationships for major military equipment and aerospace products where the original data sources consist of contractor accounting system records of past and current procurement programs.

Formal periodic reporting systems, currently required on all major aerospace contracts, have improved this situation but, to date, they have not capitalized on the capabilities of present-day electronic data processing technology for storage, retrieval, and reduction of data Exploitation of these capabilities should provide the Air Force, along with other contractees of the aerospace industry, with more useful and reliable data at a lower cost. Its benefits should accrue to data users at all levels from daily program management to long-range planning. This memorandum is addressed to the broad audience of all users of cost data.

SUMMARY

Many offices and individuals within the Federal Government are charged with analysis and control of costs, and the availability of well organized, current and historical data is essential to the discharge of this responsibility. The need for cost data has been particularly acute in the area of military equipment procurement, where it has led to the establishment of formal contractor reporting systems during the acquisition phase of procurement programs.

The output of cost reporting systems generally consists of paper (hard copy) reports. Reporting costs in this form, however, constitutes an inherent weakness of these systems. Because cost information is used for a variety of purposes ranging from daily management and control of on-going programs to planning and analyses of distant future systems, requirements for data will vary widely in amount of detail and manner of organization. Hard-copy reporting introduces inflexibility with the result that such systems cannot satisfy all users. The reports that are generated must be directed toward one or, at best, a limited number of uses or attempt to effect a compromise among conflicting requirements. In some cases valuable detail will be lost, while in other cases tedious aggregation and restructuring will be required to extract required information.

A second weakness in hard-copy systems is that reports are generated from contractor records by contractor personnel who are responsible for both interpreting reporting requirements and reducing data to conform with prescribed formats. No matter how carefully reporting requirements are formulated by the contracting agency and followed by the contractor there will still be ambiguity and misinterpretation.

An alternative to current practices is to incorporate the capabilities of electronic data processing in reporting-system design and to use magnetic tape as the primary medium for reporting and storing data. Instead of submitting printed reports, a contractor would, at the initiation of a procurement program, provide documentation of his accounting system and the program work assignment structure and, periodically during the acquisition phase, provide magnetic tape copies

of his internal accounting records. Data storage capabilities of magnetic tape are more than sufficient for the reporting and indefinite retention of highly detailed cost records. The file management capabilities of current generation computers permit the inexpensive development of generalized data-reduction and report-writing programs that can meet the requirements of diverse data users.

Organizational arrangements for processing contractor-provided magnetic-tape data may take various forms. However, the principal responsibility of the group vested with this function is to serve data users, and this implies more than merely printing and distributing a predetermined set of reports. It encompasses the development of broad data processing and interpretation capabilities responsive to the diverse requirements of all potential users. Consideration of the demand for cost data and the extensive range of associated services argues for the establishment of a separate office that would provide a wide range of data reduction and interpretation assistance on both current and past procurement programs.

To test the feasibility of cost reporting via magnetic tape, contractor-generated tapes and supplementary information were obtained on several major hardware development programs. From this sample, a single program was selected as a test case to provide insights into the nature of problems to be expected in developing and operating an automated reporting system. All major tasks associated with the system were performed, including in-depth reviews of the contractor's accounting system and the procurement program's work breakdown structure. Finally, a series of specialized paper reports, at varying levels of program detail, were printed utilizing a generalized report-generating program written for this project. Throughout this exercise no problems were encountered that could be attributed to either the basic concepts of the system or the principal elements of its implementation.

Cost reporting systems based on this concept avoid the problems inherent in current systems and appear to offer more useful and reliable data at a lower cost. The principal features of the system are the use of magnetic tape as a report medium, the preservation of data in its original detail, and the establishment of a separate service group with the responsibility of providing assistance to data users.

ACKNOWLEDGMENTS

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I. INTRODUCTION

Analysis, projection, and control of costs are responsibilities of many offices and individuals within various agencies of the Federal Government. The availability of well organized, current, and historical cost data is essential to the discharge of these responsibilities, particularly those related to the development and procurement of major military equipment and aerospace products. These data requirements have led to the establishment of formal contractor reporting systems during the acquisition phase of equipment procurement programs.

Requirements for cost data, either in the form of special studies or reporting systems, are not new: The Aeronautical Manufacturers' Planning Report (AMPR) series was started over 20 years ago. However, the past 10 to 15 years have seen a large growth of requirements for data and an accompanying establishment of comprehensive reporting systems for all major aerospace programs. An example of an early reporting system is the ballistic missile cost reports of the late 1950s. Later examples include PERT Cost Reports, the U.S. Air Force (USAF) Cost Information System (CIS), the National Aeronautics and Space Administration (NASA) 533 Form Reports, the Department of Defense (DOD) Cost Information Reports (CIRs), and the recently established Selected Acquisition Report (SAR) system.

The output of periodic reporting systems consists of paper reports (hard copy). Typically, a contractor's accounting system includes a highly detailed cost ledger system. The mass of data involved necessitates aggregation and classification when moving from cost ledgers to paper reports. In the process, substantial detail may be irretrievably lost for some users, while for others, additional and tedious aggregation may be required. In addition, the level of aggregation, data stratification, report format, and other details must be determined early in the program; it is difficult to institute later changes to meet unanticipated problems without losing the intertemporal comparability that is essential to a periodic reporting system. These are inherent shortcomings of paper report systems.

This memorandum proposes an alternative to the current practice of submitting cost reports in hard copy. All major contractors make extensive use of electronic data processing (EDP) in their accounting systems, and magnetic tape is a convenient vehicle for storing and transporting large volumes of information. Therefore, a more promising method of reporting is for contractors to submit cost data in the form of magnetic tape files containing copies of their basic accounting records and estimates of future expenditures. In Sec. II, both the current system and the proposed alternative are discussed and compared. Section III reports the results of an experimental program, employing magnetic tapes from a single procurement program, to develop and test procedures that would be embodied in cost reporting systems based on contractors' magnetic tape records. The topics discussed include the particular contractor's accounting system, required file processing procedures, and a report generating program. Conclusions are given in Sec. IV.

II. AN ALTERNATIVE REPORTING SYSTEM

PAPER (HARD COPY) REPORTING AND ITS LIMITATIONS

The basic procedures and groups involved in current reporting systems are represented in Fig. 1, although the details of the process may vary from one contract or program to the next. Reporting requirements and work statements are the result of established regulations and/or directives and contract negotiations. In many cases they are explicitly included as contract line items. The responsibility for meeting these requirements lies with the contractor group responsible for overall control of the program. The contractor's basic source of incurred cost data is his accounting system, and his responsibilities include reduction of the data, incorporation of estimated costs at program completion, analyses of variations from program norms, and preparation and distribution of printed reports. The immediate recipient of these

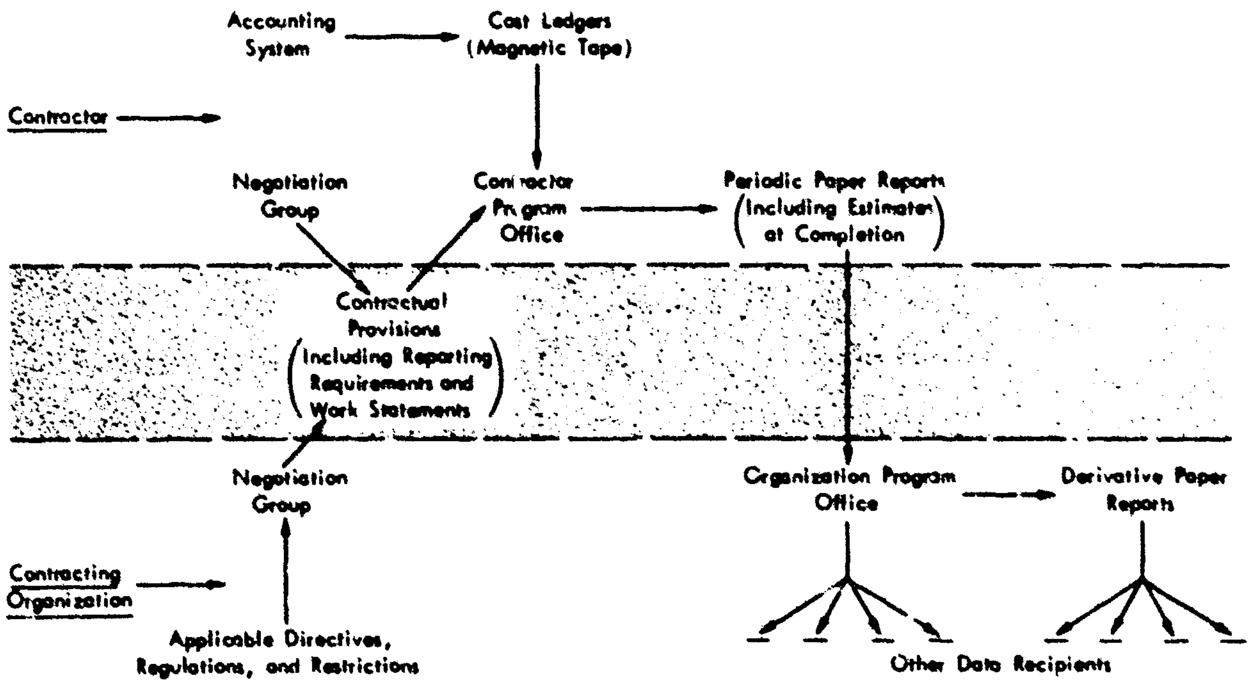

Fig. 1—Current reporting systems

reports is normally an office within the contracting organization responsible for management of the overall program, e.g., in the Air Force, the System Program Office. This office is responsible for subsequent distribution of the reports and, where required, for the development and distribution of derivative reports such as the SARs. The time-lapse between the receipt of printed reports and their delivery to their highest level recipient can be as great as 90 days.

The inherent shortcomings of paper reports can be demonstrated by considering five different uses (or users) of cost data:

1. Day-by-day management and review of on-going programs, as exemplified by system project offices, employing detailed data organized by program work statements, end items, and other contract provisions.
2. High level review and control of current programs (headquarters elements, DOD offices, Congress), requiring more aggregation than day-by-day management, but similar in organization.
3. Budgeting and funds control of current programs, organized by appropriation class.
4. Evaluation of proposals for projected programs and follow-on of current programs, requiring data organized by functional task groupings and identifying costs with capabilities and components.
5. Planning and analyses of systems proposed for distant time periods, in which data are required primarily for developing generalized estimating relationships.

In each case, data requirements obviously differ as to amount of detail, manner of classification, and length of time between the formation and the requirement for data.

Generally, contractors maintain cost ledger systems in sufficient detail to permit alternative arrangements of data. However, embodying this detail in printed reports would require hundreds of pages, and report recipients lack the resources either to analyze such detail or to aggregate and organize it into a useful product.

Conceptually, it would seem that the problem of diverse requirements could be overcome by producing a series of reports, based on the

contractor's accounting records in varying levels of detail and tailored to the needs of various recipients. This approach, however, points out an additional shortcoming of contractor-generated paper reports: No matter how carefully reporting instructions are formulated by the contracting office or how diligently they are followed by contractor personnel, there is ample room for ambiguity and misinterpretation. Since the data user is generally removed from the source of the required data--either in terms of geography, organization, or time--such ambiguities and misinterpretations are difficult if not impossible to clarify.

In any system based on contractor-generated paper reports substantial valuable information will be irretrievably lost to some users while others will require tedious aggregation or restructuring. Further, the composition of reports (such as their level of detail and classification structure) must be determined early in a program, since once paper reports have been generated, their formats become relatively frozen. It is impossible to impose a major restructuring without losing the intertemporal comparability that is required of a periodic reporting system.

A MAGNETIC TAPE REPORTING SYSTEM

An alternative to current reporting practices is to utilize magnetic tape as the principal medium for reporting and storing data. Such a system is outlined in Fig. 2. It embodies two basic changes in the current reporting system: (1) in the form of contractor submittals and (2) in the place where paper reports are developed.

Instead of submitting printed reports periodically, each contractor would provide tape copies of internal cost records (in the level of detail at which they are generated within his accounting system) and supplementary data (such as estimated costs at program completion, also on magnetic tape). At program initiation, each contractor would submit documentation of his accounting system, the program work assignment structure, and the relationship between the two. This documentation would be supplemented by updated information at appropriate intervals. Since all major contractors make extensive use of EDP for accounting functions and employ magnetic tape for data storage, the machinery to implement such a system already exists within the contractors' establishments.

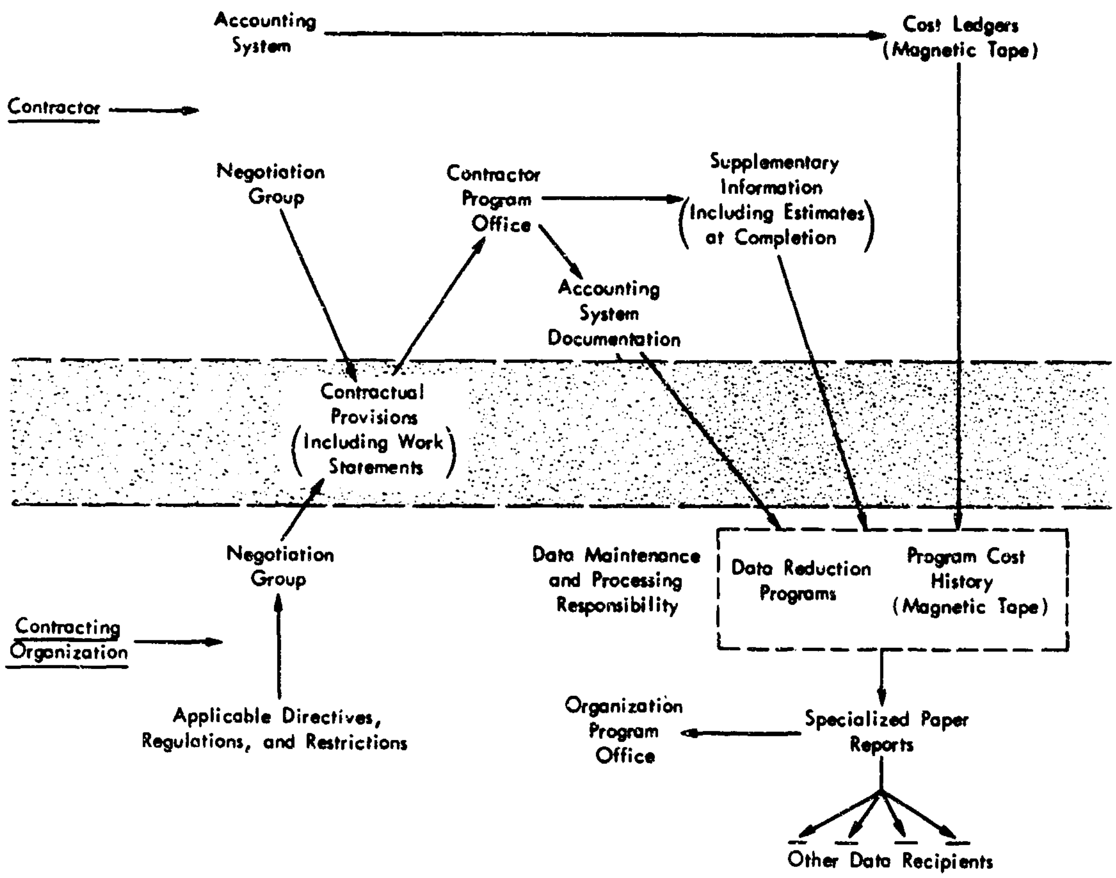

Fig. 2--Magnetic tape reporting system

It is the general practice of contractors to update cost ledgers at regular intervals by recording costs incurred since the last update as well as totaling program costs-to-date, i.e., from program inception. As a result, the data contained on contractor tapes are static representations of program cross sections at particular points in time. However, series of tape files, when merged, constitute a profile associating costs with the time period in which they were incurred and may be combined to form a single program cost history. Documentation of a contractor's accounting system provides the basis for the development of data reduction programs that, together with cost history files, will allow the generation of specialized paper reports to satisfy the requirements of a considerable variety of data users.

Procedures for processing data and printing reports may take many forms; any detailed discussion or evaluation of various arrangements

is beyond the scope of this memorandum. It is relevant, however, to consider the principal responsibilities associated with providing cost reports. Primarily, it is a service requiring a broad base of data reduction and interpretation capabilities responsive to the diverse requirements of data users. This implies an expertise in other aspects of acquisition programs and contractor accounting systems and service as a readily available "point of contact" and source of assistance for data users. Since data from a program may be used long after acquisition is completed, the files would serve as a permanent repository of historical program information maintaining accurate and complete documentation on past programs.

These responsibilities help determine the general institutional arrangement of a group charged with these functions. Since its principal function is service to all data users, such a group should be established as a separate entity without other operating responsibilities (such as current program control). Since some uses require comparably structured cross sections of data drawn from several programs (samples), responsibility for data on all programs should be vested in a single group or office. Since data have continuing applicability over time, continuity of the functions within one group and continuity of personnel are desirable. These characteristics suggest an office established at a high level within an organization, e.g., in the case of military departments as a headquarters staff function or possibly a DOD component; in the case of NASA as a staff function of the director's office.

Contractors' acceptance of reporting their costs in this fashion appears to vary widely. Discussions were held with personnel from several different companies, and reactions ranged from immediate acceptance of the concept to a half camouflaged hostility to the idea of revealing such detailed information to a contractee. They all felt that current reporting systems were of marginal value, and the required reports were rather expensive to produce. Several expressed doubts concerning the validity of the data reported since allocations of incurred costs were often required to fit established reporting categories. Some felt that a tape reporting system could not be implemented owing

to the complexity of large accounting systems. In this respect the point was missed that contractees were to establish offices that would devote their full efforts in this single direction. If contractors can develop such complex systems, contractees can understand them.

COMPARISON OF PAPER AND MAGNETIC TAPE REPORTING SYSTEMS

It is relevant to compare a reporting system based on cost data submitted on magnetic tape with current hard-copy reporting systems, particularly with respect to the current system problem areas discussed previously. A major point is the ability of each system to satisfy the requirements of diverse users, and this depends on the capability of each system to store and alternatively structure and aggregate large quantities of detailed data. The storage capacity of a single reel of tape equals that of hundreds of pages of paper reports. Because data can be stored so densely, complete program histories, say at quarterly reporting intervals, may be contained on a few reels of magnetic tape in essentially the same detail that was generated by the contractor's accounting system. This amount of detail is normally much greater than would be desired by any single user; however, it would permit the selection of cost data and their organization in alternative ways.

Data in this form assure both intertemporal comparability of records within one project and interproject comparability. In the event of extensive changes in program tasks or work statements, data from prior periods could be restructured to be consistent with current program characteristics without loss of relevant detail. The same is true of interproject comparisons: Data records from different programs could be structured in a parallel manner without loss of detail.

Extensive restructuring of program tasks can result in comparability problems--for example, changes in work breakdown structures that redefine the elements of subsystems may result in loss of detail to achieve intertemporal comparability. Similarly, different contractors may employ quite different ledger account structures, and interproject comparability can be achieved only at a level of detail where a common denominator exists. However, if accounting records in their original

detail are available, there is a high probability that comparability can be attained at the level of aggregation desired by data users.

A thorough understanding of the characteristics of contractors' accounting systems and acquisition programs is essential to intelligent use of data whether they are obtained through magnetic tape or paper reports. As suggested here, a contractee group is specifically responsible for this knowledge and may provide direct assistance to data users in interpretation and reduction of data thus assuring their compatability with users' requirements. Under these conditions, no serious problems should be encountered in developing series of specialized reports and studies.

Regardless of the form in which cost data are collected or reports generated, their usefulness is limited by contractors' accounting practices. Contractors may differ widely in this respect. Many experienced in aerospace procurement maintain highly detailed records in categories consistent with the data requirements of program management, proposal evaluation, and long-range planning. Others, however, have quite broad accounting categories that are heavily oriented toward internal management and not amenable to classification along work breakdown structure lines. In this case, current reporting requirements may compel a contractor to make arbitrary allocations of recorded costs to satisfy reporting categories. In other cases, a contractor may reach the opposite extreme of keeping records in such detail that the system essentially breaks down. The identity of expenditures for individual tasks may be lost either through inconsistent charging or repetitive redefinitions of accounts. Under current reporting systems, such practices are fairly well obscured from data users, yet awareness of where it occurs is important in understanding and reducing data. Tape reporting systems can do nothing to correct problems arising within an accounting system itself, but an understanding of the accounting system and the subsidiary documentation supplied by contractors would serve to draw attention to these problems and provide a measure of their importance to data users. The standardization of accounting procedures prescribed by the Cost/Schedule Planning Central System (C/SPCS) and the Selected Acquisition Information and Management

Systems (SAIMS) should help ameliorate this problem. Also, the accounting system documentation provided as part of a magnetic tape reporting system will provide verification of actual accounting practices.

A cost reporting system based on contractors' basic accounting records, as outlined above, appears to be free of the serious problems inherent in current paper report systems. Its principal features are the use of magnetic tape as a reporting medium, which allows the cost information to be reported in detail, and the establishment of an explicit service function for providing cost data to its various users. The remainder of this memorandum describes an experimental program to identify tasks required for implementing a reporting system based on magnetic tape records.

III. THE EXPERIMENTAL PROGRAM

The objective of the experimental program was to develop and test procedures for a cost-data reporting system based on contractor-supplied magnetic tape records and to investigate its capabilities in generating output displays to meet the requirements of a wide range of data users. Contractor-generated tapes from several major hardware development and procurement programs were collected. From this sample, the magnetic tapes from a single program were selected to provide insights into (1) the characteristics of contractor records in their original highly detailed form, and (2) the processing steps required to present the data in a form that meets user requirements.

An important use of the experimental program was to provide insights into the general problems that could be expected and where they might arise in developing and operating an automated cost reporting system. This affected both the choice of the hardware procurement program and the manner in which the data were processed. The program chosen was sufficiently near completion to insure that all major tasks had been initiated and defined in the accounting system. The contractor's accounting system and its EDP implementation were conceptually straightforward, and the program task structure was well ordered and had been relatively stable from program inception. Thus, it was felt that problems that might arise could be attributed to fundamental problems in automating cost reporting systems and not to particular or complicating characteristics of the test case. No attempt was made to optimize the procedures required for producing reports in terms of data processing, report generation, or elapsed time. The process was divided into a number of small distinct steps, and the results of each step were analyzed to provide insight into how data characteristics change and where problems of data definition and completeness might arise.

Three requirements of a viable reporting system based on magnetic tape are: (1) the association of all costs with each dimension of a predetermined classification structure, (2) the use of a small number of reels of tape to store complete program cost histories, and (3) the

ability to produce a variety of reports with moderate programming assistance and computer hardware. Each requirement was considered in the design and execution of the experimental case.

The four-way cost classification structure used has been found useful in developing cost-estimating relationships in support of program planning and proposal evaluation for aircraft, manned and unmanned spacecraft, and rocket launch vehicles. This structure was used in the experimental program, and each recorded expenditure was associated with one element of each of the four dimensions as follows:

	Examples
o Subsystem	Structure, propulsion
o Functional task	Design, production, launch operations
o Production lot or unit	-----
o Type of resource	Engineering labor hours, raw material cost

The results of the experimental case indicate that data for up to 20 reporting periods may be stored on one reel of tape while retaining the integrity of each basic work assignment identified in the contractor's accounting system. All computer processing was accomplished through either commonly available utility routines or computer programs written in widely held compiler languages and required only a moderate amount of direct access memory.

DESCRIPTION OF THE CONTRACTOR'S ACCOUNTING SYSTEM

Major hardware procurement contracts are typically let to large multidivision/plant firms that maintain extensive accounting systems containing several distinct series of records on magnetic tape, i.e., data files. Normally, one or two of these files are the basic source of the remaining files and all internal and external company reports. Individual entries (accounts) in these files are tagged with a series of identifying labels, some related only to company-wide management and planning and others related to the task structure and resource requirements of individual acquisition programs.

In the experimental program the contractor maintained two basic source files with identifying labels, the Job-Order File and Cross-

Reference File. The Job-Order File is the basic vehicle for recording incurred costs. For each combination of the relevant identifiers it contains one record showing hour and dollar expenditures during the current accounting period and totals from program inception. The Cross-Reference File is essentially a dictionary that provides a means for developing subsidiary data files from the Job-Order File; its records contain no expenditures data. The Work Breakdown Structure (WBS) File is an example of such a subsidiary file and is constructed wholly from the data contained in the two basic files. The system of identification labels is shown in Table 1. Labels noted are oriented toward functional task and type of resource and, within a single procurement program or contract, are the only ones relevant to an external reporting system.

Table 1

SYSTEM OF IDENTIFICATION LABELS

Identification Labels	*Job-Order File*	*Cross-Reference File*	*WBS File*
Job-Order[a]	x	x	
WBS[a]		x	x
Contract-Item[a]	x	x	x
Work-Element[a]	x		
Cost-Element[a]	x		x
Contract Number		x	x
Contract Class		x	x
Plant	x	x	x
Ledger	x		x
Controlling Division	x		
Account		x	
Budget		x	

[a]Oriented toward functional task and type of resource.

Job-Order is the basic (or lowest level) unit at which work is authorized and identified through the accounting system, e.g., sustaining engineering associated with one subsystem for one production lot. WBS and Contract-Item elements are aggregations of job orders and provide the basis for higher level program summaries. WBS is similar to the work breakdown structures specified for current military

acquisition programs. Contract-Item is oriented toward major contract provisions or line items such as the distinction between initial and follow-on production lots. Work-Element and Cost-Element are classifications of the type of resources expended. Work-Element identifies the departmental organization (engineering, tooling) and class of employee (direct, indirect) for labor; for nonlabor resources it identifies the purpose of expenditure (raw materials, major subcontract, computer services). Cost-Element is an amalgamation of departmental organization and the basic function of a particular job-order, i.e., it also reflects the purposes of expenditures. For example, manufacturing department personnel effort on job-orders to fabricate tools would be charged to a manufacturing work-element and to a tooling cost-element. The following lists display the contractor's Cost Element structure:

Direct Labor

Engineering
Manufacturing
Tooling
Engineering laboratory
Experimental operations
System development
Reliability
Operations reliability
Logistics support

Burden

Engineering
Manufacturing
Tooling
Engineering laboratory
Experimental operations
System development
Reliability
Operations reliability
Logistics support

Other Charges

Procurement
Raw materials
Tooling materials
Reprographic materials
Other materials
Inventories
Special equipment
Outside production
Outside engineering
Outside test
Major subcontract
Direct charges
Overtime premium

INFORMATION OBTAINED FROM THE CONTRACTOR

Two primary sources of information were provided by the contractor. The first was the Job-Order File. As explained above, this is the basic source of all dollar and hour expenditure data. The second was a printed document (Job Order Definition Document) listing each job-

order for which expenditures are authorized, giving a title and short description of each together with the WBS element to which it is assigned. The document is periodically updated as job-orders are authorized and closed. Its current edition allows for definition of approximately 20,000 job-orders. The information it contains permits association of each job-order with three dimensions of the classification structure as was shown on p. 12—subsystem, functional task, and production lot or unit.*

Other data provided by the contractor consisted of the Cross-Reference File and schedules of initiation and acceptance dates for each production item. The Cross-Reference File was used primarily for verification of the processing steps employed. The schedule data were used as background information and would be required to construct progress curves for production articles. Other background information about the program and the accounting system was obtained through discussions with contractor personnel.

FILE PROCESSING

The major steps in file processing and their sequence are shown in Fig. 3 and described below. The principle function of these steps was to augment and structure the Job-Order File in a manner to insure its consistency with the attributes of a viable automated reporting system.

The first step in processing was to develop a program task structure that conforms to the predetermined data classification structure. Conceptually, a task structure is based wholly on the requirements of ultimate data users; in fact, it is also quite dependent on the contractor's accounting system and the characteristics of the procurement program. Contractor records may not always contain the detail necessary to identify some elements of a structure based only on considerations of data use while, at the same time, allowing identification of other interesting elements to a level of detail that could not be

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*The fourth dimension, type of resource, was provided by the cost-element identifier associated with individual records of the Job-Order File.

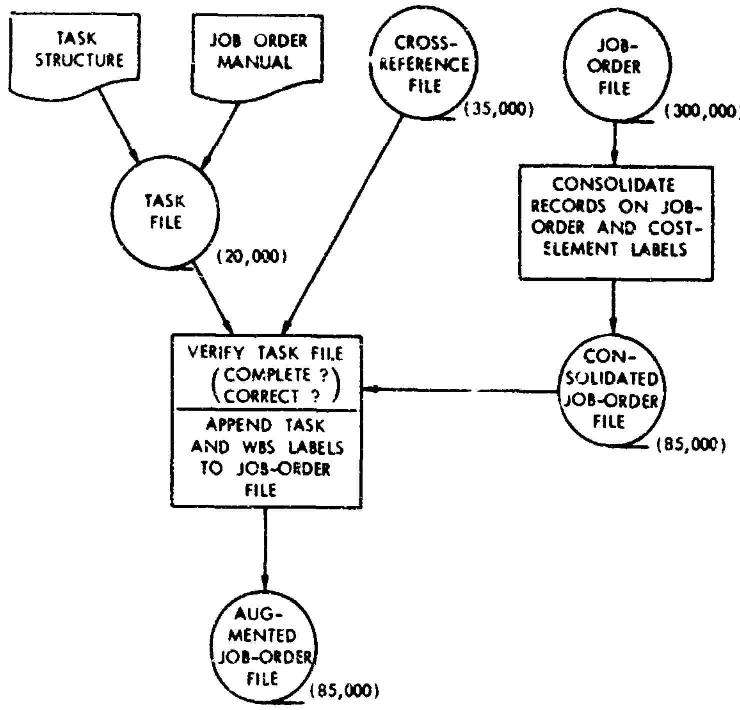

Fig. 3--Major steps in file processing

anticipated beforehand. The task structure that was developed for the experimental program evolved as a result of considerations of data use and a detailed study of the program's job-order system. Each element is described by a five-digit number. Its major headings and first digit of the five-digit number are as follows:

- 1, Flight Hardware Design and Development.
- 2, Flight Hardware Test Articles, Models, and Mockups.
- 3, Remote Site Development Test and Support.
- 4, Flight Hardware Manufacturing, Tooling, and Test Equipment.
- 5, Ground Equipment Design and Development.
- 6, Ground Equipment Manufacturing and Tooling.
- 7, Launch Operations Support.
- 0, Other Program Costs.

Table 3 displays the composition of the design and development heading. The composition of the last four digits depends on the value of the first digit.

Table 2

STRUCTURE OF FLIGHT HARDWARE DESIGN AND DEVELOPMENT TASKS

Description of Values	Value
First digit	
Flight Hardware Design and Development	1
Second and third digits, Model and Subsystem	
Model A	
Integrated system[a]	10
Structural subsystem	11
Propulsion subsystem	12
Electrical subsystem	13
Instrumentation subsystem	14
Flight control subsystem	15
Auxiliary propulsion subsystem	16
Other/subsystem common	19
Model B	
Integrated system[a]	20
Structural subsystem	21
Propulsion subsystem	22
Electrical subsystem	23
Instrumentation subsystem	24
Flight control subsystem	25
Auxiliary propulsion subsystem	26
Other/subsystem common	29
Fourth and fifth digits, Type of Task	
Design/development engineering and studies	01
Manufacturing support[b]	02
Development test[c]	03
Qualification test[c]	04
Development test[d]	06
Manufacturing/tooling design and research	07
Other/nonseparable[c]	09
Preliminary design	20
First article configuration inspection	31
Other/miscellaneous	90

NOTE: Five digit number (xxxxx): first digit = 1 indicates Flight Hardware Design and Development; second and third digits indicate Model and Subsystem; fourth and fifth digits indicate Type of Task.

[a]Includes AGE interface.

[b]Includes tooling and quality control.

[c]In-plant.

[d]Remote site.

The next processing step was to associate each job-order described in the Job-Order Manual with a single element of the task structure. The output of this step was a magnetic tape file--the Task File. Each of the 20,000 job-orders defined in the manual forms a separate record in this file and contains the job-order number, the element in the task and WBS structures to which it belongs, and the page in the job-order manual containing its description. Developing the task structure, including the assignment of tasks to job-orders and preparation of the file, was the most time consuming operation, accounting for roughly 60 percent of the total file processing effort.

The third step was to verify the task file. The first task in this was to consolidate the cross-reference and job-order files. Since other identifiers are associated with each record, a given job-order may appear more than once within the cross-reference file. As a result, it was consolidated to eliminate all multiple appearances of a given job-order. Similarly, multiple appearances of the same job-order/cost-element combination occur in the job-order file. Consolidation of this file resulted in the one-time appearance of each job-order/cost-element combination with the dollar and hour expenditures associated with it equal to the sum of all records with that job-order/cost-element value in the original file.

Once consolidated, these files were used to validate the task file. The consolidated cross-reference file served to verify the accuracy of the task file: For each entry in the task file, there should be a record in the cross-reference file with a corresponding job-order/WBS combination.* For each record verified, the associated contract-item value was appended in the task file.

The consolidated job-order file served to verify the completeness of the task file: For each job-order record, there should be a single record in the task file with equal job-order/contract-item values.

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*The cross-reference file could not verify completeness of the task file since a significant portion consisted of unused job-order values reserved by the contractor prior to the beginning of the procurement program. In most cases, the job-orders falling in this category were tagged with a special WBS value.

For each verified record, the associated task and WBS values were appended in the consolidated job-order file. The end product of this step was the augmented job-order file discussed below. The location and cause of all errors and omissions in the task file were identified during these processing steps. The task file was then corrected and both steps repeated until all records had been verified.

With the exception of consolidating the job-order file, the major portions of the process described above would be performed only once during the life cycle of an acquisition program. Once the task file has been defined and verified, it may be kept current through updating to account for new job-order authorizations, modification of work statements, and other program changes. This holds whether automated reporting is initiated at program inception or later.

If automated reporting had been instituted at the inception of this procurement program, the initial steps required to develop the augmented job-order file would have been different and more straightforward because much of the information required would be a by-product of program definition. This is typical of major acquisition programs. Initial program composition and subsequent changes are not adequately reflected in later program documentation, and much useful background information is never formally documented. Awareness of this is important both in understanding and in processing program cost data and is difficult to trace at a later point.

AUGMENTED JOB-ORDER FILE CHARACTERISTICS

This file, or its counterpart in other contractors' systems, is the key to a viable, automated cost reporting system. It is the single source of data for all uses. As such, it [illegible] provide sufficient detail and allow for a variety of data organizations; it must be an efficient storage device and be amenable to change (reformatting and updating). At the same time, it must be easy to use in producing printed reports. In the experimental program, the file appears to meet the above criteria.

The format of individual records is displayed in Table 3. The original detail embodied in the contractor's accounting system is

Table 3

AUGMENTED JOB-ORDER FILE FORMAT

Name of Field	*Length of Field (Characters)*	*Length of Logical Record*
Task structure label	5	
Job-order label	8	
Reference	8	
Cost-element label	2	
WBS label	16	
Contract-item label	7	
Reporting period 1		
Total to date, hr	11	
Total to date, $	11	68
Reporting period 2		
Total to date, hr	11	
Total to date, $	11	90
Reporting period 3		
Total to date, hr	11	
Total to date, $	11	112
.		
.		
.		
Reporting period n		

preserved insofar as job-order and cost-element identification is concerned. The field titled "Reference" provides the page reference in the contractor's accounting manual where the job-order is described. All dollar and hour expenditures associated with one job-order are contained in a single record regardless of the number of reporting periods involved. As a result, the length of a single logical record varies with the number of periods, thus a complete program history containing the temporal profile of expenditures resides in one file.

Since both WBS and contract-item are aggregations of job-orders, they have the same characteristics as the task structure developed for the experimental program. In effect, this provides for alternative data stratifications of the file itself as follows:

First Identifier	*Second Identifier*
Job-order	Cost-element
WBS	Cost-element
Contract-item	Cost-element

In this case, alternative stratification is an accident resulting from the contractor's accounting system. However, it can also be the result

of intentional design. The use of several different task structures may prove to be an efficient tool for reconciling conflicting data requirements of different users.

Consolidation of the original job-order file resulted in a reduction in the number of logical records by a factor of almost four with a similar reduction in the volume of magnetic tape required--from 75 percent to 20 percent of one reel for two reporting periods. At this rate, 4 years of quarterly reports could be stored on one reel of tape when recorded in a density of 1600 bits per inch (the highest density currently available).

The development of dynamic cost histories requires the task file and the job-order file to be updated at each reporting interval. Figure 4 displays the general updating procedure for each file. In essence, it parallels the procedures used in developing the files originally but is noticeably simpler. It is also possible to revise the total task structure or formulate additional task structures by use of this procedure.

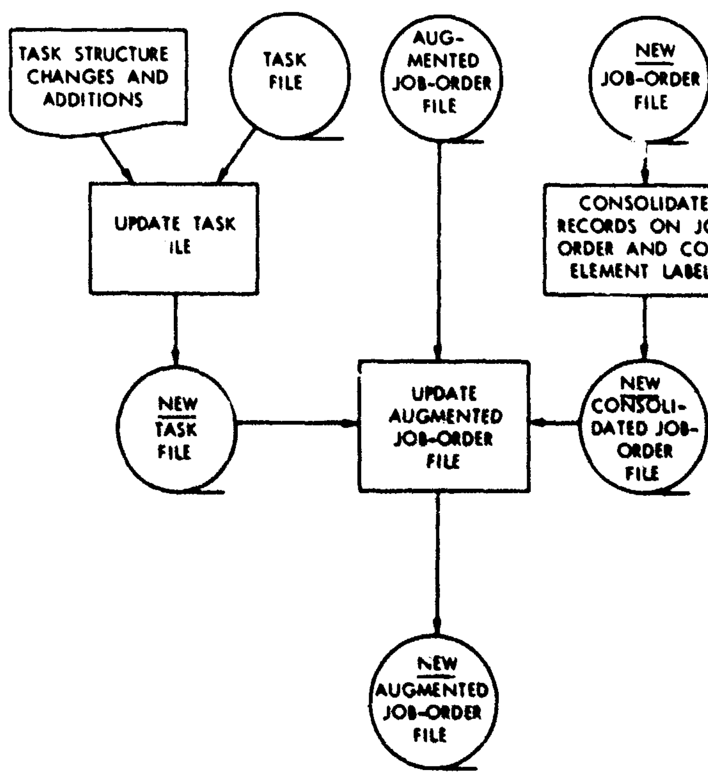

Fig. 4—Updating procedures

REPORT GENERATING PROGRAM

The job-order file may be used to generate a variety of printed reports. The reports shown in Figs. 5 and 6 were generated by using a computer program written specifically for this purpose. Figure 5 is a highly aggregated program summary while Fig. 6 is a quite detailed record of expenditures associated with the in-plant design and development effort associated with a single subsystem (structure). Additional program output displays are shown in the appendix. Several desired characteristics were considered in designing the computer program, the foremost being that it should have the capability of producing reports in widely varying levels of detail. The program defines a matrix of up to 50 rows and up to 54 columns: The actual number of rows and columns utilized in any run and which of each are devoted to summations of other rows and columns are specified through input data cards. Input data consist of the augmented job-order file and punched cards that associate given values of task and cost-element with particular cells of the matrix. The column and row to which a datum is assigned depends on the values of task and cost-element, respectively, with which it is associated. Detail embodied in the reports can be as aggregated as total program costs and as fine as that identified in the task structure.

A second desired characteristic was that the program should be hardware-independent and usable by a variety of medium and large size general purpose computers. This affects the choice of programming language and core storage requirements. The current program is written in COBOL, a compiler available to most current computers. Required core storage amounts to 80,000 bytes on the IBM 360 series computers. With minor program changes, assignment of data to columns may be based on either WBS or contract-item labels.

USE OF MULTIPLE COST FILES

Major procurement programs are characterized by extensive subcontracting, and current reporting systems call for estimates of cost at program completion. The result is that a prime contractor's file of

	PROGRAM TOTAL	FLIGHT HARDWARE RDT/E	FLIGHT HARDWARE PRODUCTION	AEROSPACE GROUND EQUIP	PROGRAM PLANNING	PROGRAM MISCELLANEOUS
HOURS						
DIRECT LABOR						
ENGINEERING	20,518,105	14,964,150	83,277	2,431,587	1,902,022	1,137,069
ENGINEERING SUPPORT	5,766,515	5,339,574	340	346,591	7,853	72,158
MANUFACTURING	14,948,074	2,940,349	6,799,779	4,729,175	53,738	425,034
TOOLING	6,049,810	209,482	4,646,295	1,138,184	48,777	7,072
QUALITY CONTROL	4,537,607	736,383	2,593,937	996,114	102,534	108,640
LOGISTICS SUPPORT	772,596	94,262	86	2,650	25,656	649,942
TOTAL	52,592,707	24,284,198	14,123,713	9,644,301	2,140,579	2,399,915
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING	111,732	81,512	476	11,835	11,179	6,730
ENGINEERING SUPPORT	24,639	22,855	1	1,459	37	287
MANUFACTURING	52,702	10,218	24,616	16,068	254	1,545
TOOLING	22,182	801	17,028	4,106	218	29
QUALITY CONTROL	18,412	2,824	10,805	3,792	523	467
LOGISTICS SUPPORT	3,693	452		13	127	3,101
TOTAL	233,360	118,661	52,927	37,274	12,338	12,159
OVERHEAD						
ENGINEERING	12[illegible],751	92,[illegible]70	551	13,246	12,770	7,695
ENGINEERING SUPPORT	27,722	25,838	1	1,513	42	327
MANUFACTURING	56,637	10,990	26,464	17,248	274	1,661
TOOLING	23,874	861	18,356	4,390	236	31
QUALITY CONTROL	19,889	3,110	11,635	4,073	565	505
LOGISTICS SUPPORT	3,451	428		13	121	2,889
TOTAL	258,325	133,717	57,007	40,483	14,009	13,109
OTHER						
MATERIALS	57,722	16,336	21,701	17,646	733	1,306
SUBCONTRACT	38,680	5,169	30,101	2,059	83	1,268
OUTSIDE TEST	6,778	6,294		471		13
CONTRACT ENGINEERING	3,609	2,863	17	481	119	130
PURCHASED EQUIPMENT	40,520	6,415	20,634	13,360	12	99
OTHER	13,728	2,175	3,513	2,19[illegible]	2,668	3,174
TOTAL	161,039	39,252	75,967	36,216	3,615	5,989
GENERAL & ADMINISTRATIVE	103,611	55,132	24,877	17,083	5,802	5,718
TOTAL PROGRAM	761,334	346,762	210,778	131,056	35,763	36,975

Fig. 5—Program summary

	ENGINEERING	MANUFACTURING SUPPORT	IN-PLANT TEST	OTHER	TOTAL
DIRECT HOURS					
ENGINEERING	420,061		360,730		780,791
ENGINEERING SUPPORT			1,093,941	10	1,093,951
MANUFACTURING/TOOLING	13	142,217	3,287	31,971	177,488
QUALITY CONTROL	280	6,050	32,361		38,591
LOGISTICS SUPPORT					
TOTAL DIRECT HOURS	420,354	148,267	1,490,319	31,982	2,090,921
LABOR DOLLARS (DIRECT & OVERHEAD)					
ENGINEERING	4,650		4,023		8,573
ENGINEERING SUPPORT			9,098		9,098
MANUFACTURING/TOOLING		983	21	218	1,223
QUALITY CONTROL	2	45	249		296
LOGISTICS SUPPORT					
TOTAL I OR DOLLARS	4,653	1,028	13,391	218	19,290
OTHER DOLLARS					
MATERIALS	218	65	1,895		2,178
SUBCONTRACT	28		705		734
OUTSIDE TEST			212		212
CONTRACT ENGINEERING	72		52		124
PURCHASED EQUIPMENT			198		198
OTHER	47	22	287	1	357
TOTAL OTHER DOLLARS	365	87	3,349	2	3,802
GENERAL AND ADMINISTRATIVE	996	241	2,913	45	4,195
TOTAL PROGRAM DOLLARS	6,014	1,355	19,654	265	27,288

NOTE: ALL DOLLAR VALUES IN THOUSANDS

Fig. 6--Structure system: Design/development and in-plant test

incurred costs will not suffice for developing a cost history or for meeting program reporting and control requirements.

Subcontractor costs are typically not reported to the prime contractor in the same manner or detail as maintained either in the subcontractor's or prime contractor's in-plant systems. Incorporation of subcontract costs may be accomplished in two manners. The first is to retain separate magnetic tape files of the incurred costs of each significant subcontract; the second is to merge the cost records of significant subcontractors into the prime contractor file. In either case, magnetic tapes must also be obtained from subcontractors, and reported costs must be organized around the same task structure employed for the prime contractor's records.*

Current reporting systems generally require the display of estimated costs at program completion for major tasks that are spelled out either in the reporting system instructions or as a product of program definition. Since estimates at completion cannot be made in the detail desirable for displaying incurred costs (the task structure), separate tape files must be maintained for each. Further, more than one reporting system may be imposed on a single procurement program, and there is no guarantee that the composition of reporting categories, and hence estimated costs at completion, associated with one report will be consistent with those of another.

No attempt was made in the experimental case to develop procedures for handling multiple files. However, the problem is recognized as being important for both current program reporting and the development of cost histories and should be investigated as one of the next steps in developing a magnetic tape reporting system.

At this time it is difficult to estimate the costs involved in implementing a tape reporting system or to compare its costs with those of current hard-copy systems. The experimental program was intended only to determine the feasibility of magnetic tape reporting, and the

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*There is little to distinguish interdivisional work authorizations from subcontracting in this respect. Both may present similar data processing problems since different divisions of the same firm may employ different accounting systems.

approach adopted was tailored toward this single end. The procurement program was selected to avoid extraneous problems arising from unusual technical or accounting problems. Although the exercise was incomplete in the sense that subcontractor data and estimates at completion were not incorporated, other processing steps were required that would not be performed in actually implementing the system. The total effort, including study of the contractor's accounting system, development of the Task Structure, all file processing, and printing of the reports shown in the appendix, required approximately 6 man-months. Considering that a large portion of this effort needs to be performed only once during the life-cycle of a procurement program, magnetic tape reporting systems, at the very least, appear to be competitive with current hard-copy systems in terms of cost.

IV CONCLUSIONS

From the investigations to date, there appears to be no reason to question the conceptual soundness of using contractors' magnetic tape for reporting cost data. In addition, a magnetic tape reporting system seems to avoid some serious problems found in hard-copy reporting systems, such as inconsistent reporting and inflexible reports.

The mechanics of implementation seem to be straightforward, although problems rooted in idiosyncrasies of different contractor accounting systems and procurement programs can be expected to arise. However, problems of this type are also present, although not always apparent, in paper reporting systems.

Considerable work remains to be done, however, prior to any large-scale implementation of the system. Further study of processing tape records and estimates at program completion should be conducted and both the program management and historical documentation aspects of the system should be tested in an operational environment. Instituting tape reporting as a requirement of a new procurement program, on an experimental basis, would provide insights into its potential that could not be obtained in any other manner. This would also provide an excellent opportunity for investigating alternative organizations for the data maintenance and processing function.

In general, a reporting system based on magnetic tape records of cost data offers so many distinct and valuable advantages over hard-copy reporting systems that substantial, empirical research of its feasibility and cost aspects should be undertaken. The accuracy, comparability, and easy availability of the data to cost analysts involved in long-range weapon acquisition studies, alone, could result in substantial savings.

APPENDIX

The four example cost reports shown below were printed by the report generating program developed for this project. The program has the capability for printing both titles and explanatory footnotes. Table 4 is an expansion of the program summary displayed in Fig. 5. The tasks (columns) identified in Table 4 are shred-outs of those shown in Fig. 5.

Table 5 shows the subsystem breakout of flight hardware design and development and in-plant test (columns 1 and 2 of Table 4). It is noteworthy that only 25 percent of the cost of design and development is charged to identifiable subsystems while the remaining 75 percent is charged to the categories "integrated system" and "subsystem common." Certainly there are design tasks that can be identified only with the vehicle as a whole or with more than one subsystem, but it is questionable that such a large proportion should fall in this category. The program's work order document contains several entries describing this type of effort in addition to work orders identifying design effort by individual subsystem. It is difficult to escape the conclusion that a careful review of design and development expenditures would permit identification of a higher proportion of charges with individual subsystems.

Table 6 displays the production costs of operational flight hardware and major test articles (included under "test parts/simulators/mock-ups" in Table 4) by model and production lot. Tooling costs and a sizable portion of quality control are charged as a common expense to groups of production lots. The data displayed are not sufficient for developing progress curves. At the time the job-order file was obtained, the program was still in its acquisition phase, and production had not been completed on the later lots of either model. Further production of the two models proceeded concurrently and supplementary milestone schedule information would be required to determine a true production sequence. Table 7 contains the subsystem detail of one lot group displayed in Table 6.

Table 4

PROGRAM SUMMARY

	FLIGHT HARDWARE DESIGN/DEVEL	IN-PLANT DEVEL TEST	REMOTE SITE TEST & SUPPORT	TEST PARTS/SIMULATORS/MOCKUPS	TOTAL RDT/E	FLIGHT HARDWARE MODEL A *
HOURS						
DIRECT LABOR						
ENGINEERING	11,013,274	1,535,074	1,891,265	509,668	14,949,281	1,460
ENGINEERING SUPPORT	34,549	4,697,495	97,900	509,629	5,339,574	305
ENGINEERING PLANNING	3,899		10,970		14,869	
MANUFACTURING	166,920	71,891	677,466	2,024,072	2,940,349	3,482,099
TOOLING	56,587	2,415	127,276	23,204	209,482	3,366,523
QUALITY CONTROL	34,763	318,008	119,785	263,827	736,383	1,642,355
LOGISTICS SUPPORT	2,213	21,783	64,972	5,293	94,262	86
TOTAL DIRECT HOURS	11,312,204	6,646,667	2,989,634	3,335,694	24,284,198	8,492,827
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING	59,733	8,527	10,549	2,611	81,420	7
ENGINEERING SUPPORT	150	20,457	456	1,791	22,855	1
ENGINEERING PLANNING	23		68		92	
MANUFACTURING	569	235	2,654	6,760	10,218	12,948
TOOLING	201	8	506	86	801	12,390
QUALITY CONTROL	149	1,242	491	942	2,824	6,924
LOGISTICS SUPPORT	11	105	311	25	452	
TOTAL DIRECT DOLLARS	60,838	30,573	15,036	12,214	118,661	32,271
OVERHEAD						
ENGINEERING	67,596	9,730	12,078	2,980	92,385	7
ENGINEERING SUPPORT	170	23,160	521	1,987	25,838	1
ENGINEERING PLANNING	27		78		105	
MANUFACTURING	614	251	2,848	7,277	10,990	13,945
TOOLING	218	9	544	90	861	13,376
QUALITY CONTROL	163	1,401	525	1,021	3,110	7,462
LOGISTICS SUPPORT	11	98	295	24	428	
TOTAL OVERHEAD	68,799	34,650	16,889	13,379	133,717	34,792
OTHER						
MATERIALS	3,919	7,377	1,074	3,967	16,336	15,103
SUBCONTRACT	1,689	1,787	552	1,141	5,169	23,375
OUTSIDE TEST	3	6,122	31	140	6,294	
CONTRACT ENGINEERING	2,210	397	62	195	2,863	15
PURCHASED EQUIPMENT	35	1,574	754	4,052	6,415	13,705
OTHER	1,463-	1,402	1,327	908	2,175	1,933
TOTAL OTHER DOLLARS	6,393	18,659	3,798	10,402	39,252	53,832
GENERAL & ADMINISTRATIVE	28,079	14,341	7,091	5,621	55,132	15,067
TOTAL PROGRAM DOLLARS	164,108	98,223	42,815	41,616	346,762	135,961

* OPERATIONAL FLIGHT HARDWARE

Table 4--continued

	FLIGHT HARDWARE MODEL B *	FLIGHT HARDWARE SPARES	FLIGHT HARDWARE TOTAL	AGE DEVELOPMENT	AGE PRODUCTION	AGE SPARES
HOURS						
DIRECT LABOR						
ENGINEERING	81,817		83,277	2,425,291	6,296	
ENGINEERING SUPPORT	35		340	335,129	11,462	
ENGINEERING PLANNING						
MANUFACTURING	3,266,118	51,537	6,799,754	2,055	4,596,488	130,632
TOOLING	1,279,772		4,646,295		1,138,184	
QUALITY CONTROL	936,410	15,163	2,593,927	20,787	926,171	49,156
LOGISTICS SUPPORT			86		2,650	
TOTAL DIRECT HOURS	5,564,153	66,700	14,123,680	2,783,262	6,681,251	179,789
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING	469		476	11,806	30	
ENGINEERING SUPPORT			1	1,411	48	
ENGINEERING PLANNING						
MANUFACTURING	11,492	175	24,616	7	15,627	434
TOOLING	4,638		17,028		4,106	
QUALITY CONTROL	3,825	56	10,805	79	3,545	169
LOGISTICS SUPPORT					13	
TOTAL DIRECT DOLLARS	20,425	232	52,927	13,303	23,369	603
OVERHEAD						
ENGINEERING	543		551	13,214	32	
ENGINEERING SUPPORT			1	1,458	55	
ENGINEERING PLANNING						
MANUFACTURING	12,331	187	26,464	8	16,771	470
TOOLING	4,980		18,356		4,390	
QUALITY CONTROL	4,113	60	11,635	88	3,804	181
LOGISTICS SUPPORT					13	
TOTAL OVERHEAD	21,968	247	57,007	14,767	25,065	551
OTHER						
MATERIALS	6,439	159	21,701	2,248	12,543	2,855
SUBCONTRACT	6,358	668	30,101	35	1,977	47
OUTSIDE TEST				471		
CONTRACT ENGINEERING	2		17	465	16	
PURCHASED EQUIPMENT	6,483	446	20,634	85	12,310	965
OTHER	1,565	16	3,513	783	1,378	36
TOTAL OTHER DOLLARS	20,846	1,289	75,967	4,087	28,224	3,905
GENERAL & ADMINISTRATIVE	9,700	109	24,877	6,043	10,754	286
TOTAL PROGRAM DOLLARS	72,939	1,877	210,777	38,200	87,412	5,444

* OPERATIONAL FLIGHT HARDWARE

Table 4 --continued

	AGE TOTAL	LAUNCH OPS. & SUPPORT	PROGRAM PLANNING	LOGISTICS SUPPORT/DATA	PROGRAM MISCELLANEOUS	PROGRAM TOTAL
HOURS						
DIRECT LABOR						
ENGINEERING	2,431,587	375,375	833,032	369,090	144,954	19,186,595
ENGINEERING SUPPORT	346,591	2,977	7,853	26,485	42,696	5,766,515
ENGINEERING PLANNING		226,867	1,068,990	16,902	3,882	1,331,509
MANUFACTURING	4,729,175	6,414	53,738	244,166	174,461	14,948,057
TOOLING	1,138,184		48,777	415	6,657	6,049,810
QUALITY CONTROL	996,114	5,047	102,534	71,963	31,631	4,537,598
LOGISTICS SUPPORT	2,650		25,656	634,512	15,430	772,596
TOTAL DIRECT HOURS	9,644,301	616,680	2,140,579	1,363,532	419,711	52,592,681
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING	11,835	2,235	4,829	2,043	889	103,727
ENGINEERING SUPPORT	1,459	15	37	96	175	24,639
ENGINEERING PLANNING		1,435	6,350	105	24	8,005
MANUFACTURING	16,068	30	254	824	691	52,702
TOOLING	4,106		218	2	27	22,182
QUALITY CONTROL	3,792	24	523	310	134	18,412
LOGISTICS SUPPORT	13		127	3,024	77	3,693
TOTAL DIRECT DOLLARS	37,274	3,739	12,338	6,404	2,017	233,359
OVERHEAD						
ENGINEERING	13,246	2,577	5,506	2,328	1,006	117,597
ENGINEERING SUPPORT	1,513	17	42	109	202	27,722
ENGINEERING PLANNING		1,638	7,264	121	26	9,154
MANUFACTURING	17,248	33	274	887	742	56,637
TOOLING	4,390		236	2	29	23,874
QUALITY CONTROL	4,073	25	565	336	144	19,889
LOGISTICS SUPPORT	13		121	2,817	72	3,451
TOTAL OVERHEAD	40,483	4,290	14,009	6,598	2,221	258,325
OTHER						
MATERIALS	17,646	106	733	799	400	57,722
SUBCONTRACT	2,059		83	36	1,232	38,680
OUTSIDE TEST	471				13	6,778
CONTRACT ENGINEERING	481	18	119	105	7	3,609
PURCHASED EQUIPMENT	13,360		12	3	96	40,520
OTHER	2,198	237	2,668	2,386	551	13,728
TOTAL OTHER DOLLARS	36,216	361	3,615	3,328	2,299	161,039
GENERAL & ADMINISTRATIVE	17,083	1,780	5,802	2,991	947	108,611
TOTAL PROGRAM DOLLARS	131,056	10,169	35,763	19,321	7,484	761,334

* OPERATIONAL FLIGHT HARDWARE

Table 5

FLIGHT HARDWARE DESIGN/DEVELOPMENT AND IN-PLANT TEST
BY SUP-SYSTEM

	TOTAL DES/DEVEL & IN-PLANT TEST	TOTAL DES/DEVEL	TOTAL IN-PLANT TEST	OTHER DEVEL TASKS
DIRECT HOURS				
ENGINEERING	12,552,247	10,875,360	1,535,074	141,813
ENGINEERING SUPPORT	4,732,044	34,537	4,697,495	12
MANUFACTURING/TOOLING	297,813	222,601	74,306	906
QUALITY CONTROL	352,771	26,374	318,008	8,389
LOGISTICS SUPPORT	23,996	2,120	21,783	93
TOTAL DIRECT HOURS	17,958,870	11,160,991	6,646,667	151,213
LABOR DOLLARS (DIRECT & OVERHEAD)				
ENGINEERING	145,637	126,123	18,257	1,257
ENGINEERING SUPPORT	43,937	320	43,617	
MANUFACTURING/TOOLING	2,105	1,594	503	7
QUALITY CONTROL	2,955	230	2,643	82
LOGISTICS SUPPORT	225	22	203	1
TOTAL LABOR DOLLARS	194,859	128,289	65,223	1,347
OTHER DOLLARS				
MATERIALS	11,296	3,863	7,377	55
SUBCONTRACT	3,476	1,689	1,787	
OUTSIDE TEST	6,124	3	6,122	
CONTRACT ENGINEERING	2,606	2,209	397	
PURCHASED EQUIPMENT	1,610	35	1,574	
OTHER *	60-	1,571-	1,402	108
TOTAL OTHER DOLLARS	25,052	6,229	18,659	163
GENERAL AND ADMINISTRATIVE	42,420	27,841	14,341	238
TOTAL PROGRAM DOLLARS	262,331	162,359	98,223	1,749

* INCLUDES COST TRANSFERS
NOTE: ALL DOLLAR VALUES IN THOUSANDS

Table 5--continued

	INTEG SYSTEM DES/DEVEL	INTEG SYSTEM IN-PLANT TEST	INTEG SYSTEM SUB-SYS TOTAL	STRUCTURE DES/DEVEL	STRUCTURE IN-PLANT TEST	STRUCTURE SUB-SYS TOTAL
DIRECT HOURS						
ENGINEERING	5,870,389	71,126	5,941,515	420,061	360,730	780,791
ENGINEERING SUPPORT	17,242	678,917	696,159	10	1,093,941	1,093,951
MANUFACTURING/TOOLING	5,210	307	5,517	174,202	3,287	177,488
QUALITY CONTROL	10,473	5,292	15,765	6,330	32,361	38,691
LOGISTICS SUPPORT	781		781			
TOTAL DIRECT HOURS	5,904,094	755,642	6,659,736	600,603	1,490,319	2,090,921
LABOR DOLLARS (DIRECT & OVERHEAD)						
ENGINEERING	69,421	768	70,189	4,650	4,023	8,673
ENGINEERING SUPPORT	154	7,190	7,344		9,098	9,098
MANUFACTURING/TOOLING	36	2	38	1,202	21	1,223
QUALITY CONTROL	94	42	137	47	249	296
LOGISTICS SUPPORT	8		8			
TOTAL LABOR DOLLARS	69,713	8,002	77,715	5,899	13,391	19,290
OTHER DOLLARS						
MATERIALS	1,697	194	1,890	283	1,895	2,178
SUBCONTRACT	54		54	28	705	734
OUTSIDE TEST	3	56-	53-		212	212
CONTRACT ENGINEERING	1,477	6	1,483	72	52	124
PURCHASED EQUIPMENT	17	6	23		198	198
OTHER *	7,052-	33	7,019-	70	287	357
TOTAL OTHER DOLLARS	3,805-	183	3,622-	454	3,349	3,802
GENERAL AND ADMINISTRATIVE	15,171	1,749	16,920	1,281	2,913	4,195
TOTAL PROGRAM DOLLARS	81,079	9,934	91,013	7,634	19,654	27,288

* INCLUDES COST TRANSFERS
NOTE: ALL DOLLAR VALUES IN THOUSANDS

Table 5--continued

	PROPULSION DES/DEVEL	PROPULSION IN-PLANT TEST	PROPULSION SUB-SYS TOTAL	ELECTRICAL DES/DEVEL	ELECTRICAL IN-PLANT TEST	ELECTRICAL SUB-SYS TOTAL
DIRECT HOURS						
ENGINEERING	1,024,441	572,607	1,597,047	409,854	150,965	560,819
ENGINEERING SUPPORT	15,618	1,643,973	1,659,591	1,630	455,835	457,465
MANUFACTURING/TOOLING	15,089	5,459	20,548	17,208	1,838	19,046
QUALITY CONTROL	7,811	207,092	214,903	279	23,002	23,280
LOGISTICS SUPPORT	19	20,442	20,461	160	1,322	1,482
TOTAL DIRECT HOURS	1,062,978	2,449,572	3,512,550	429,131	632,962	1,062,093
LABOR DOLLARS (DIRECT & OVERHEAD)						
ENGINEERING	11,747	7,076	18,823	4,014	1,816	5,830
ENGINEERING SUPPORT	152	15,386	15,538	13	4,138	4,151
MANUFACTURING/TOOLING	136	36	172	132	12	144
QUALITY CONTROL	75	1,752	1,827	2	184	187
LOGISTICS SUPPORT		191	191	2	12	14
TOTAL LABOR DOLLARS	12,109	24,441	36,550	4,163	6,162	10,325
OTHER DOLLARS						
MATERIALS	460	3,519	3,979	433	616	1,048
SUBCONTRACT	1,581	1,046	2,627	14	13	26
OUTSIDE TEST		5,518	5,518		168	168
CONTRACT ENGINEERING	291	196	487	98	70	167
PURCHASED EQUIPMENT	18	1,014	1,032	1	127	128
OTHER *	290	868	1,158	86	83	170
TOTAL OTHER DOLLARS	2,641	12,161	14,802	631	1,076	1,707
GENERAL AND ADMINISTRATIVE	2,618	5,425	8,043	893	1,345	2,238
TOTAL PROGRAM DOLLARS	17,368	42,027	59,395	5,687	8,583	14,270

* INCLUDES COST TRANSFERS
NOTE: ALL DOLLAR VALUES IN THOUSANDS

Table 5--continued

	INSTRUMENTATION DES/DEVEL	INSTRUMENTATION IN-PLANT TEST	INSTRUMENTATION SUB-SYS TOTAL	FLIGHT CONTROL DES/DEVEL	FLIGHT CONTROL IN-PLANT TEST	FLIGHT CONTROL SUB-SYS TOTAL
DIRECT HOURS						
ENGINEERING	546,365	121,088	667,452	94,300	76,349	170,648
ENGINEERING SUPPORT		331,890	331,890		248,149	248,149
MANUFACTURING/TOOLING	3,336	939	4,275	338	1,154	1,493
QUALITY CONTROL	254	10,100	10,354	30	17,684	17,714
LOGISTICS SUPPORT					3	3
TOTAL DIRECT HOURS	549,955	464,016	1,013,971	94,668	343,338	438,306
LABOR DOLLARS (DIRECT & OVERHEAD)						
ENGINEERING	5,711	1,465	7,176	1,041	902	1,942
ENGINEERING SUPPORT		3,099	3,099		2,255	2,255
MANUFACTURING/TOOLING	22	6	29	2	7	10
QUALITY CONTROL	2	83	85		146	146
LOGISTICS SUPPORT						
TOTAL LABOR DOLLARS	5,736	4,653	10,389	1,043	3,309	4,353
OTHER DOLLARS						
MATERIALS	587	366	953	30	419	449
SUBCONTRACT	3		3	1		1
OUTSIDE TEST		168	168		105	105
CONTRACT ENGINEERING	105	31	136	11	25	36
PURCHASED EQUIPMENT		27	27		80	80
OTHER *	56	42	98	8	37	45
TOTAL OTHER DOLLARS	751	634	1,385	49	667	716
GENERAL AND ADMINISTRATIVE	1,239	1,021	2,260	222	718	940
TOTAL PROGRAM DOLLARS	7,726	6,308	14,034	1,315	4,694	6,009

* INCLUDES COST TRANSFERS
NOTE: ALL DOLLAR VALUES IN THOUSANDS

Table 5--continued

	OTHER/COMMON DES/DEVEL	OTHER/COMMON IN-PLANT TEST	OTHER/COMMON SUB-SYS TOTAL
DIRECT HOURS			
ENGINEERING	2,509,951	182,210	2,692,161
ENGINEERING SUPPORT	37	244,791	244,828
MANUFACTURING/TOOLING	7,218	61,322	68,540
QUALITY CONTROL	1,197	22,480	23,677
LOGISTICS SUPPORT	1,160	16	1,176
TOTAL DIRECT HOURS	2,519,563	510,818	3,030,381
LABOR DOLLARS			
(DIRECT & OVERHEAD)			
ENGINEERING	29,539	2,208	31,747
ENGINEERING SUPPORT		2,451	2,452
MANUFACTURING/TOOLING	64	418	482
QUALITY CONTROL	10	186	196
LOGISTICS SUPPORT	12		12
TOTAL LABOR DOLLARS	29,626	5,264	34,890
OTHER DOLLARS			
MATERIALS	374	369	743
SUBCONTRACT	9	23	32
OUTSIDE TEST		6	6
CONTRACT ENGINEERING	156	17	173
PURCHASED EQUIPMENT		123	123
OTHER *	4,970	53	5,023
TOTAL OTHER DOLLARS	5,509	590	6,099
GENERAL AND ADMINISTRATIVE	6,417	1,169	7,586
TOTAL PROGRAM DOLLARS	41,552	7,023	48,575

* INCLUDES COST TRANSFERS
NOTE: ALL DOLLAR VALUES IN THOUSANDS

Table 6

FLIGHT HARDWARE PRODUCTION BY MODEL, LOT, AND LOT GROUP*

	MODEL B TEST ARTICLES	MODEL B LOT 1	MODEL B LOT 2	MODEL B - LOT GROUP 1 COMMON	MODEL B - LOT GROUP 1 TOTAL	MODEL B LOT 3
HOURS						
DIRECT LABOR						
ENGINEERING						7,775
ENGINEERING SUPPORT						
MANUFACTURING	344,436	376,712	1,098,996	32,832	1,852,975	542,975
TOOLING				535,023	535,023	56
QUALITY CONTROL	42,836	63,928	212,211	210,359	529,334	102,192
TOTAL DIRECT HOURS	387,272	440,640	1,311,207	778,214	2,917,332	652,998
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING						47
ENGINEERING SUPPORT						
MANUFACTURING	1,130	1,297	3,785	172	6,383	1,930
TOOLING				1,960	1,960	
QUALITY CONTROL	151	234	787	974	2,147	389
TOTAL DIRECT DOLLARS	1,281	1,531	4,572	3,106	10,490	2,366
OVERHEAD						
ENGINEERING				1	1	56
ENGINEERING SUPPORT						
MANUFACTURING	1,213	1,384	[illegible]047	184	6,828	2,074
TOOLING				2,108	2,108	
QUALITY CONTROL	162	250	843	1,042	2,298	419
TOTAL OVERHEAD	1,376	1,634	4,890	3,335	11,235	2,549
OTHER						
MATERIALS	539	488	1,425	750	3,203	858
SUBCONTRACT	130	162	771	1,596	2,658	350
PURCHASED EQUIPMENT	649	400	1,753	5	2,807	852
OTHER	94	205	417	102	819	153
TOTAL OTHER DOLLARS	1,412	1,256	4,366	2,454	9,487	2,213
GENERAL AND ADMINISTRATIVE	594	707	2,171	1,442	4,914	1,148
TOTAL PROGRAM DOLLARS	4,663	5,127	15,998	10,337	36,126	8,277

* INCLUDES TOOLING AND TEST EQUIPMENT WORK ORDERS

Table 6--continued

	MODEL B LOT 4	MODEL B LOT 5	MODEL B LOT 6	MODEL B - LOT GROUP 2 COMMON	MODEL B - LOT GROUP 2 TOTAL	MODEL A TEST ARTICLES
HOURS						
DIRECT LABOR						
ENGINEERING					7,775	
ENGINEERING SUPPORT						
MANUFACTURING	441,439	368,866	288,328	32,993	1,674,601	1,189,288
TOOLING				146,257	146,313	
QUALITY CONTROL	80,897	67,495	47,866	100,675	399,126	149,538
TOTAL DIRECT HOURS	522,335	436,361	336,193	279,926	2,227,814	1,338,826
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING					47	
ENGINEERING SUPPORT						
MANUFACTURING	1,541	1,300	998	176	5,946	3,956
TOOLING				591	591	
QUALITY CONTROL	304	255	180	494	1,622	532
TOTAL DIRECT DOLLARS	1,845	1,555	1,178	1,261	8,[illegible]06	4,487
OVERHEAD						
ENGINEERING					56	
ENGINEERING SUPPORT						
MANUFACTURING	1,662	1,401	1,075	190	6,403	4,248
TOOLING				635	635	
QUALITY CONTROL	328	275	194	533	1,749	512
TOTAL OVERHEAD	1,991	1,676	1,269	1,358	8,843	4,820
OTHER						
MATERIALS	678	733	652	209	3,130	2,028
SUBCONTRACT	339	592	504	1,088	2,873	776
PURCHASED EQUIPMENT	857	836	917		3,462	3,164
OTHER	96	82	46	22	399	418
TOTAL OTHER DOLLARS	1,970	2,243	2,118	1,320	9,864	6,383
GENERAL AND ADMINISTRATIVE	906	755	566	605	3,980	2,378
TOTAL PROGRAM DOLLARS	6,[illegible]	6,228	5,131	4,544	30,893	17,769

* INCLUDES TOOLING AND TEST EQUIPMENT WORK ORDERS

Table 6--continued

	MODEL A LOT 1	MODEL A LOT 2	MODEL A - LOT GROUP 1 COMMON	MODEL A - LOT GROUP 1 TOTAL	MODEL A LOT 3	MODEL A LOT 4
HOURS						
DIRECT LABOR						
ENGINEERING						
ENGINEERING SUPPORT			15	15		
MANUFACTURING	716,258	523,462	65,926	2,594,934	497,361	107,650
TOOLING			2,104,184	2,104,184		
QUALITY CONTROL	113,479	121,352	770,133	1,154,501	95,392	25,957
TOTAL DIRECT HOURS	829,737	744,814	2,940,258	5,853,635	592,753	133,606
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING						
ENGINEERING SUPPORT						
MANUFACTURING	2,510	2,253	225	8,944	1,841	403
TOOLING			7,633	7,633		
QUALITY CONTROL	422	467	3,313	4,734	375	103
TOTAL DIRECT DOLLARS	2,932	2,721	11,171	21,311	2,215	506
OVERHEAD						
ENGINEERING						
ENGINEERING SUPPORT						
MANUFACTURING	2,698	2,433	243	9,522	1,988	435
TOOLING			8,251	8,251		
QUALITY CONTROL	455	504	3,553	5,085	404	111
TOTAL OVERHEAD	3,152	2,938	12,047	22,957	2,393	546
OTHER						
MATERIALS	1,138	973	3,804	7,943	894	179
SUBCONTRACT	588	411	15,427	17,200	653	15
PURCHASED EQUIPMENT	1,697	1,372	1,052	7,285	1,355	66
OTHER	205	185	400	1,208	106	19
TOTAL OTHER DOLLARS	3,629	2,941	20,683	33,636	3,008	280
GENERAL AND ADMINISTRATIVE	1,411	1,325	5,116	9,930	1,063	238
TOTAL PROGRAM DOLLARS	11,124	9,924	49,017	87,834	8,679	1,570

* INCLUDES TOOLING AND TEST EQUIPMENT WORK ORDERS

Table 6--continued

	MODEL A - LOT GROUP 2 COMMON	MODEL A - LOT GROUP 2 TOTAL	MODEL A LOT 5	MODEL A LOT 6	MODEL A LOT 7	MODEL A - LOT GROUP 3 COMMON
HOURS						
DIRECT LABOR						
ENGINEERING						
ENGINEERING SUPPORT						
MANUFACTURING	52,669	657,680	456,143	312,019	201,931	2,233
TOOLING	63,221	63,221				151,844
QUALITY CONTROL	149,903	271,251	93,699	45,917	18,185	189,486
TOTAL DIRECT HOURS	265,792	992,152	549,841	357,936	220,116	343,563
DOLLARS (THOUSANDS)						
DIRECT LABOR						
ENGINEERING						
ENGINEERING SUPPORT						
MANUFACTURING	183	2,427	1,637	1,117	723	9
TOOLING	283	283				6[illegible]
QUALITY CONTROL	676	1,154	362	177	70	89[illegible]
TOTAL DIRECT DOLLARS	1,143	3,864	1,999	1,294	793	1,558
OVERHEAD						
ENGINEERING						
ENGINEERING SUPPORT						
MANUFACTURING	199	2,622	1,759	1,202	777	10
TOOLING	304	304				714
QUALITY CONTROL	735	1,251	390	191	75	966
TOTAL OVERHEAD	1,239	4,176	2,150	1,393	852	1,689
OTHER						
MATERIALS	408	1,481	1,282	1,054	905	170
SUBCONTRACT	895	1,563	148	59	31	3,112
PURCHASED EQUIPMENT	1,078	2,500	1,751	1,759	500	61
OTHER	44	169	74	37	19	11
TOTAL OTHER DOLLARS	2,424	5,713	3,254	2,909	1,454	3,355
GENERAL AND ADMINISTRATIVE	545	1,846	935	606	371	737
TOTAL PROGRAM DOLLARS	5,351	15,600	8,338	6,201	3,470	7,338

* INCLUDES TOOLING AND TEST EQUIPMENT WORK ORDERS

Table 6--Continued

	MODEL A - LOT GROUP 3 TOTAL	MODEL B COMMON TASKS	MODEL A COMMON TASKS	TOTAL FLIGHT HARDWARE
HOURS				
DIRECT LABOR				
ENGINEERING		74,042	1,460	83,277
ENGINEERING SUPPORT		35	290	340
MANUFACTURING	972,326	79,591	446,447	8,278,654
TOOLING	151,844	596,504	1,047,274	4,644,363
QUALITY CONTROL	347,286	4,476	18,854	2,724,828
TOTAL DIRECT HOURS	1,471,456	754,749	1,514,325	15,731,462
DOLLARS (THOUSANDS)				
DIRECT LABOR				
ENGINEERING		422	7	476
ENGINEERING SUPPORT			1	1
MANUFACTURING	3,486	281	2,048	29,514
TOOLING	659	2,078	3,815	17,020
QUALITY CONTROL	1,498	15	69	11,239
TOTAL DIRECT DOLLARS	5,643	2,796	5,940	58,250
OVERHEAD				
ENGINEERING		487	7	551
ENGINEERING SUPPORT			1	1
MANUFACTURING	3,747	301	2,201	31,725
TOOLING	714	2,227	4,108	18,346
QUALITY CONTROL	1,623	16	75	12,097
TOTAL OVERHEAD	6,084	3,031	6,392	62,720
OTHER				
MATERIALS	3,411	512	4,296	24,077
SUBCONTRACT	3,350	653	1,737	30,033
PURCHASED EQUIPMENT	4,070	830	3,014	23,969
OTHER	141	435	847	4,018
TOTAL OTHER DOLLARS	10,972	2,531	9,895	82,097
GENERAL AND ADMINISTRATIVE	2,648	1,298	2,722	27,337
TOTAL PROGRAM DOLLARS	25,347	9,656	24,948	230,405

* INCLUDES TOOLING AND TEST EQUIPMENT WORK ORDERS

Table 7

FLIGHT HARDWARE – MODEL A – LOT GROUP 3
PRODUCTION BY SUBSYSTEM

	LOT 5 STRUCTURE	LOT 5 PROPULSION	LOT 5 ELECTRICAL	LOT 5 INSTRUMENTATION	LOT 5 FLIGHT CONTROL	LOT 5 ASSEMBLY
HOURS						
DIRECT						
MANUFACTURING	199,603	73,985	46,765	11,010	743	124,037
TOOLING						
QUALITY CONTROL	22,870	16,373	7,362	2,502	936	43,646
TOTAL	222,473	90,358	54,128	13,511	1,680	167,683
DOLLARS (THOUSANDS)						
LABOR *						
MANUFACTURING	1,465	568	314	77	6	967
TOOLING						
QUALITY CONTROL	179	131	58	20	7	356
TOTAL	1,644	699	373	97	13	1,323
OTHER						
MATERIALS	510	327	217	39	7	182
SUBCONTRACT	51	44	4	1		48
PURCHASED EQUIPMENT	527	705	168	59	61	231
OTHER	22	17	2			32
TOTAL	1,109	1,092	392	100	69	492
GENERAL & ADMINISTRATIVE	370	157	83	22	3	300
TOTAL	3,123	1,948	848	219	85	2,115

* DIRECT AND OVERHEAD
** TOOLING, SUBCONTRACT AND QUALITY CONTROL

Table 7--continued

	LOT 5 TOTAL	LOT 6 STRUCTURE	LOT 6 PROPULSION	LOT 6 ELECTRICAL	LOT 6 INSTRUMENTATION	LOT 6 FLIGHT CONTROL
HOURS						
DIRECT						
MANUFACTURING	456,143	168,848	45,934	32,828	9,348	552
TOOLING						
QUALITY CONTROL	93,690	18,683	6,308	4,955	1,865	302
TOTAL	549,833	187,532	52,242	37,783	11,213	854
DOLLARS (THOUSANDS)						
LABOR *						
MANUFACTURING	3,397	1,249	354	225	65	4
TOOLING						
QUALITY CONTROL	752	146	51	40	15	2
TOTAL	4,148	1,394	405	265	80	6
OTHER						
MATERIALS	1,282	450	271	179	35	6
SUBCONTRACT	148	30	23	1		
PURCHASED EQUIPMENT	1,751	535	642	148	82	31
OTHER	73	17	9	1	1	
TOTAL	3,254	1,032	945	329	118	37
GENERAL & ADMINISTRATIVE	935	312	91	60	18	1
TOTAL	8,337	2,739	1,441	654	216	45

* DIRECT AND OVERHEAD
** TOOLING, SUBCONTRACT AND QUALITY CONTROL

Table 7--continued

	LOT 6 ASSEMBLY	LOT 6 TOTAL	LOT 7 STRUCTURE	LOT 7 PROPULSION	LOT 7 ELECTRICAL	LOT 7 INSTRUMENTATION
HOURS						
DIRECT						
MANUFACTURING	54,509	312,019	121,923	40,104	13,290	3,987
TOOLING						
QUALITY CONTROL	13,804	45,917	10,833	3,393	1,021	518
TOTAL	68,312	357,936	132,756	43,496	14,311	4,505
DOLLARS (THOUSANDS)						
LABOR *						
MANUFACTURING	423	2,319	895	308	93	31
TOOLING						
QUALITY CONTROL	114	368	86	26	8	4
TOTAL	537	2,687	982	334	102	35
OTHER						
MATERIALS	111	1,053	416	250	13[illegible]	19
SUBCONTRACT	4	59	5	19		
PURCHASED EQUIPMENT	321	1,759	182	89	64	14
OTHER	9	37	10	7		
TOTAL	445	2,907	612	365	197	33
GENERAL & ADMINISTRATIVE	123	606	221	75	23	8
TOTAL	1,105	6,200	1,815	775	322	76

* DIRECT AND OVERHEAD
** TOOLING, SUBCONTRACT AND QUALITY CONTROL

Table 7--continued

	LOT 7 FLIGHT CONTROL	LOT 7 ASSEMBLY	LOT 7 TOTAL	GROUP COMMON MANUFACTURING	LOT GROUP OTHER **	LOT GROUP TOTAL
HOURS						
DIRECT						
MANUFACTURING	500	22,024	201,828	2,233		972,223
TOOLING					151,844	151,844
QUALITY CONTROL	177	2,227	18,169	604	188,882	347,261
TOTAL	677	24,252	219,997	2,836	340,727	1,471,328
DOLLARS (THOUSANDS)						
LABOR *						
MANUFACTURING	4	168	1,499	18		7,232
TOOLING					1,373	1,373
QUALITY CONTROL	1	18	145	5	1,851	3,121
TOTAL	5	186	1,644	23	3,224	11,726
OTHER						
MATERIALS	6	83	905	16	154	3,410
SUBCONTRACT		6	31	1	3,112	3,350
PURCHASED EQUIPMENT		151	500	65	4-	4,070
OTHER		2	19		11	140
TOTAL	6	242	1,454	82	3,273	10,970
GENERAL & ADMINISTRATIVE	1	42	371	5	731	2,648
TOTAL	12	470	3,469	110	7,228	25,344

* DIRECT AND OVERHEAD
** TOOLING, SUBCONTRACT AND QUALITY CONTROL

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10. ABSTRACT

As an alternative to the current practice of submitting cost reports on paper, this study suggests incorporating the capabilities of electronic data processing in the design of reporting systems and using magnetic tape as the primary medium for reporting and storing data. Instead of submitting printed reports, a contractor would provide documentation of his accounting system and work assignment structure at the initiation of a procurement program, and provide periodic tape copies of his internal accounting records during the acquisition phase. A sample program was selected as a test case and all major tasks were performed, including in-depth reviews of the contractor's accounting system and the procurement program's work breakdown structure. A series of specialized paper reports were printed using a generalized report-generating program written for the project. No problems were encountered that could be attributed to the basic concepts of the system or to the principal elements of implementation.

11. KEY WORDS

Cost Analysis
Information Processing
Contracts